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LINEAR MEASUREMENT: A METHOD OF ESTIMATING FASCICLE NUMBERS FOR LARCH CASEBEARER POPULATION SAMPLING

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ABSTRACT

Branch samples collected from 23 plots in northern Idaho and western Montana in 1975 had a combined mean distribution of 3.13 fascicles/inch (1.23 fascicles/cm) of branch length. By subsampling, it is possible to determine cumulative lineal inches of branch necessary to obtain a sampling unit of 100 fascicles for a plot, eliminating the need for counting fascicles on each sample.

KEYWORDS: *Coleophora laricella*, larch casebearer, population sampling

Customarily, larch casebearer populations have been sampled by taking four 18-inch (45.7 cm) long branches per tree at midcrown and determining the number of larch casebearer per 100 fascicles (spur shoots) (Webb 1953, 1957; Eidmann 1965; Rush 1972; Ciesla and Bousfield 1974). A requirement of this method is counting fascicles to determine a uniform sampling unit of 100 fascicles. In 1975, we began work to develop a means of sampling population intensities of the larch casebearer that would eliminate the need to count fascicles on each branch sample, which would be more efficient and equally accurate.

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METHODS

Branch samples were collected from 23 plots in northern Idaho and western Montana during April and June 1975 (fig. 1). Four branches were collected at midcrown, with pole pruners, from each of 5 to 10 trees on each plot. In the laboratory, 100 fascicles were counted on each branch, starting from the distal end. Lengths of branches were then measured and recorded for each sample of 100 fascicles. Measurements were expressed as mean numbers of fascicles per inch of branch per plot.

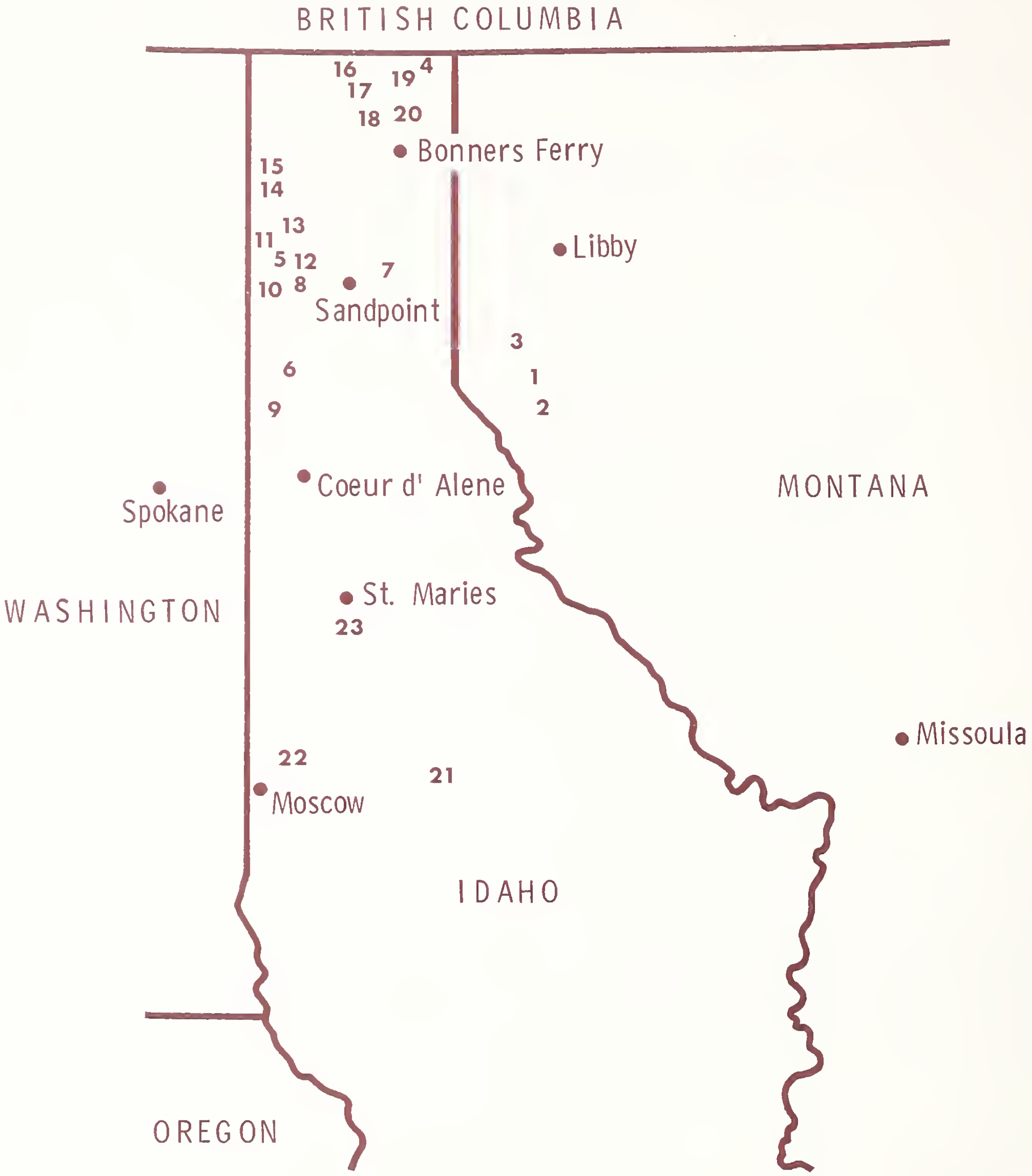

Figure 1.--Plot locations for larch casebearer sampling in northern Idaho and western Montana.

RESULTS

Sample plots over a large geographic area provided a range of mean fascicles per inch of growth from a low of 2.45 (0.96/cm) to a high of 3.55 (1.40/cm) (table 1).

Table 1.--*Mean fascicles/inch/plot*

Plot	n	Mean fascicles/inch	Mean fascicles/cm	$\pm S_{\bar{x}}$[1]
1	28	2.87	1.13	0.0577
2	40	2.97	1.17	.0723
3	39	2.45	0.96	.0616
4	40	3.55	1.40	.0752
5	16	3.36	1.32	.1279
6	40	3.10	1.22	.0860
7	40	3.02	1.19	.1112
8	39	3.11	1.22	.0562
9	40	3.22	1.27	.0730
10	37	3.51	1.38	.1136
11	25	3.10	1.22	.0732
12	38	2.86	1.13	.0612
13	36	2.94	1.16	.0742
14	40	3.38	1.33	.0554
15	31	2.96	1.17	.0591
16	40	3.35	1.32	.1217
17	40	2.96	1.17	.0553
18	40	2.71	1.07	.0576
19	40	3.26	1.28	.0772
20	40	3.38	1.33	.1230
21	60	3.06	1.20	.0529
22	55	3.29	1.30	.0757
23	60	3.32	1.31	.0993
All plots combined	904	3.13	1.23	.0192

[1] Expressed in fascicles/inch.

Pooling data from all plots provided a mean of 3.13 fascicles per inch (1.23 fascicles/cm) of branch growth, with a $S_{\bar{x}} = 0.0192$. At this fascicle density, 32 inches (81.28 cm) of lineal growth would have provided a sample base of 100 fascicles on these plots, as shown in the following tabulation:

Fascicles/inch	*Fascicles/cm*	*Sample length** *(Inches)*
2.4	0.94	42
2.5	0.98	40
2.6	1.02	39
2.7	1.06	37
2.8	1.10	36
2.9	1.14	34
3.0	1.18	33
3.1	1.22	32
3.2	1.26	31
3.3	1.30	30
3.4	1.34	29
3.5	1.38	29
3.6	1.42	28
3.7	1.46	27

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*Sample length rounded off to nearest inch.

Variation in fascicle density between plots may be explained by tree characteristics such as branch growth rate as influenced by stand density, dominance, and previous insect and disease activity.

RECOMMENDATIONS AND CONCLUSIONS

To allow for variation in fascicle density between plots and to maintain a uniform sampling procedure between plots, a 36-cumulative-lineal-inch (91.4-cm) sample of six 6-inch (15.24-cm) samples per branch is recommended. This would assure that enough sample material is collected in the field to minimize the possibility of not achieving a mean 100-fascicle sampling unit for a plot at the time of laboratory examination. The extra sample length should accommodate any variation in fascicle density that may arise between plots. However, if a branch at the time of collection appears atypical, the collector should count 100 fascicles to maintain the 100-fascicle sample base.

The sampling procedure would consist of collecting a branch from a tree (fig. 2), which would then be cut into six 6-inch (15.24-cm) pieces as shown in figure 3. This same procedure would be continued until the entire plot had been sampled. Upon completion of the sample collection, a 10-percent subsample of the samples for a plot would be used to calibrate the remaining samples to a 100-fascicle sampling unit for the plot. On each branch in the subsample, 100 fascicles would be counted and the

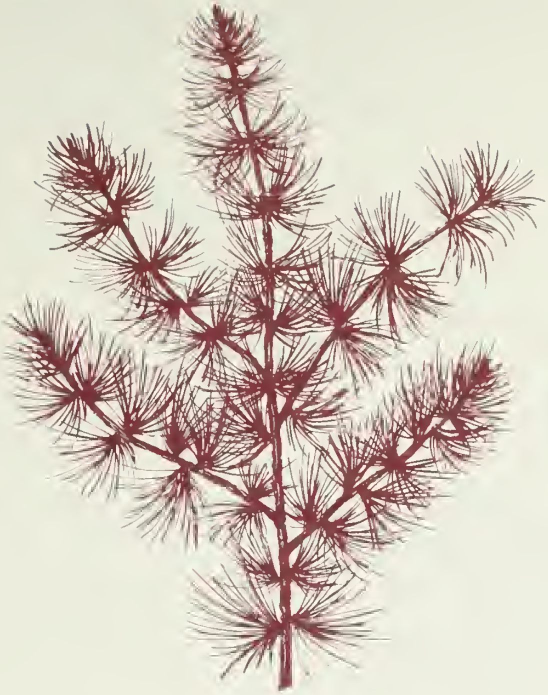

Figure 2.--Larch branch collected from midcrown.

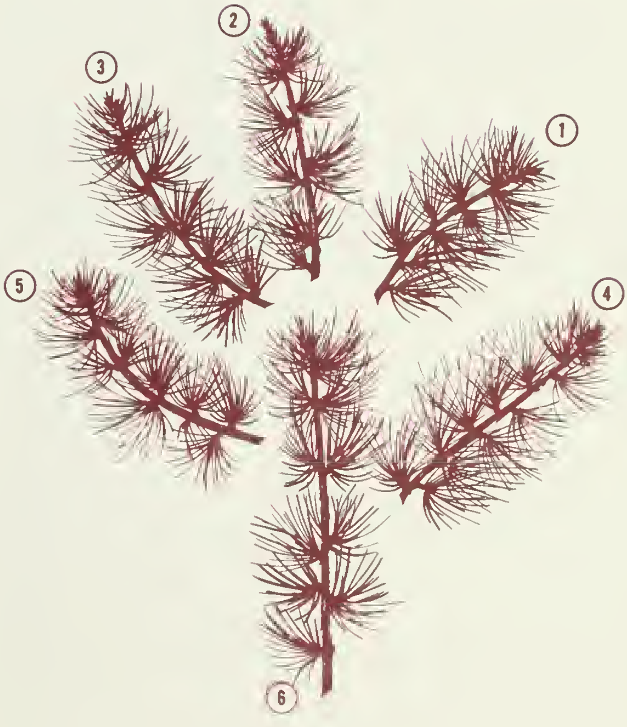

Figure 3.--An illustration of a 36-cumulative-lineal-inch (91.4-cm) sample of six 6-inch (15.24-cm) samples per branch to obtain 100 fascicles.

cumulative branch length recorded. The mean fascicle density for the plot would be calculated and the sample length for the remaining branches determined as shown in the following example.

Plot sample:

10 trees
40 branches, 4/tree at midcrown

Subsample calibration:

Subsample No.	*Fascicles*	*Inches*	*Fascicles/inch*
1	100	33	3.03
2	100	29	3.45
3	100	30	3.33
4	100	31	3.23

With a mean fascicle density of 3.26/inch (1.28/cm) for the plot, the required sample length for the remaining samples would be:

$$\frac{100 \text{ fascicles}}{3.26} = 31 \text{ inches (sample length rounded off to nearest inch).}$$

Verification

This sampling procedure was applied to larch casebearer pupal population sampling on 12 plots in 1977. Four branches were collected at midcrown from 18 trees on plots 1 through 6 and 10 trees on plots 7 through 12. Each plot was individually calibrated using a 10 percent subsample. Plot means for fascicle density were calculated and the sample lengths for the remaining branches were determined (table 2).

Table 2.---*Results of subsample calibrations on 12 plots 1977*

Plot	n	$\bar{x}$ fascicles/inch	$\bar{x}$ fascicles/cm	Sample length applied to remaining samples
				Inches
1	8	3.53	1.39	29
2	8	3.45	1.36	29
3	8	3.33	1.31	30
4	8	3.36	1.32	30
5	8	3.26	1.28	31
6	8	3.35	1.32	30
7	6	3.38	1.33	30
8	6	3.66	1.44	28
9	4	3.70	1.46	27
10	4	3.26	1.28	31
11	6	3.30	1.30	30
12	6	2.96	1.17	34

To determine how well this method of estimating 100 fascicles worked, all branches (excluding those used for calibrating the plots) were reexamined and the actual number of fascicles per branch recorded. A chi-square test was used to test the hypothesis that the estimated sampling unit was within ±10 percent of a mean 100-fascicle sampling unit for each plot at the 10 percent significance level as shown (Freese 1960).

$$\chi^2_{(n)df} = \frac{\sum_{i=1}^{n} (x_i - \mu_i)^2}{\sigma^2}$$

x_i = estimated number of fascicles in the i^{th} plot using the new technique
μ_i = actual number of fascicles in the i^{th} plot using the standard technique
n = number of plots
σ^2 = the required accuracy (for example ±10 percent of the mean at the 10 percent significance level)

The calculated χ^2 value at 12 df was 1.69 corresponding to a table value of 18.5 at the 10 percent significance level. Therefore, the results of this study indicate that the proposed sampling design satisfies the accuracy requirements specified.

Although the variation in number of fascicles between branches may be relatively high within a plot, the mean number of fascicles per branch for a plot is very close to 100 (table 3).

By using a linear measurement sampling method and a 10 percent subsample to calibrate individual plots, it is possible to determine cumulative lineal inches of branch necessary to obtain a uniform 100-fascicle sampling unit for a plot without counting fascicles. Accuracy was maintained and efficiency was improved by using this sampling procedure with the sampling being completed in one-half the time compared to when fascicles were previously counted.

The authors feel this method of sampling will also apply to any life stage of the larch casebearer where population levels are expressed as number of insects per 100 fascicles.

Table 3.--*Mean fascicles per branch by plot*

Plot	n	$\bar{x}$	$S_{\bar{x}}$	Range	
				Minimum	Maximum
1	64	98.5	1.2067	74	117
2	64	101.8	1.4187	77	130
3	64	96.9	1.4505	69	119
4	64	97.5	1.4658	72	127
5	64	103.2	1.5753	74	144
6	64	101.4	1.1041	80	122
7	34	100.9	1.8638	78	117
8	34	97.2	2.0575	72	130
9	36	102.4	1.6844	81	122
10	36	102.4	1.3264	88	125
11	34	99.7	2.2505	63	116
12	34	97.0	1.3008	81	115
All plots combined	592	99.96	0.4511	63	144

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